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SEEDING HABITS OF UPPER-SLOPE TREE SPECIES
II. DISPERSAL OF A MOUNTAIN HEMLOCK SEEDCROP ON A CLEARCUT

by

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ABSTRACT

Mountain hemlock seedfall declined rapidly beyond one tree height from the stand edge (125 feet). Central portions of the 30-acre clearcut still received 50,000 to 100,000 sound seeds per acre during a very heavy seed year. Therefore, seedling germination or establishment appears to be the major problem in regenerating mountain hemlock on clearcuts.

Keywords: Seed dispersal, seedling survival, mountain hemlock, *Tsuga mertensiana*.

Seed supply is a key element in natural regeneration of forest stands. Consequently, seeding habits received early attention in a research program on natural regeneration of upper-slope forests begun in 1961. An initial long-term study involves cone production by selected species (Franklin 1968, Franklin et al. 1974). In 1967, research was extended to measurements of seedfall to relate the cone production data to viable seed production and measure dissemination on partially cut and clearcut areas. These and other studies of upper-slope seeding habits continue. Rather than waiting until all are completed, we will report results of small but self-contained study segments which are valuable in providing foresters with guidelines for selection of silvicultural techniques.

Dissemination of a bumper 1968 mountain hemlock (*Tsuga mertensiana*) seed crop on a clearcut in the southern Oregon Cascade Range is the subject of this report. Most data concern relationships between seedfall and distance from seed source. Although based on a single case history, this report provides information useful in evaluating seed supply as a limiting factor in natural regeneration and in selecting clearcut sizes suitable for mountain hemlock forests. Data from a somewhat smaller seed crop in 1971 confirm the 1968 results.

STUDY METHODS

The clearcut studied is located on gently sloping topography at about 5,400-foot elevation near Diamond Lake in the Crater Lake Province, Oregon High Cascades (Franklin 1965). The 31-acre tract was logged in 1961 as part of the Windigo Pass Timber Sale, and there has been very little revegetation since then. The surrounding stand is dominated by mountain hemlock (92 percent of the stems) with lesser amounts of Shasta red fir (*Abies magnifica* var. *shastensis*) and western white pine (*Pinus monticola*). Characteristics of the mountain hemlock stand component adjacent to the four seed trap transects are as follows (height is average of two dominant trees, and basal area and trees per acre are for trees over 5-inch d.b.h. on a 1-acre plot):

Clearcut edge	Tree height (Feet)	Basal area (Ft^2/acre)	Trees (Number/acre)
North	70	149	277
South	97	410	357
West	140[1/]	258	380
East	77	240	324

Dominants averaged 225 years in age based on stump counts; the stand adjacent to the north transect appeared somewhat younger than the remainder of the bordering forest.

[1/] Based on Shasta red fir trees; mountain hemlock dominants averaged 25 to 35 feet shorter.

Seed production and dissemination were measured using four groups of four-seed-trap transects extending at right angles from each of the timber edges toward the center of the clearcut (fig. 1). Sixteen traps

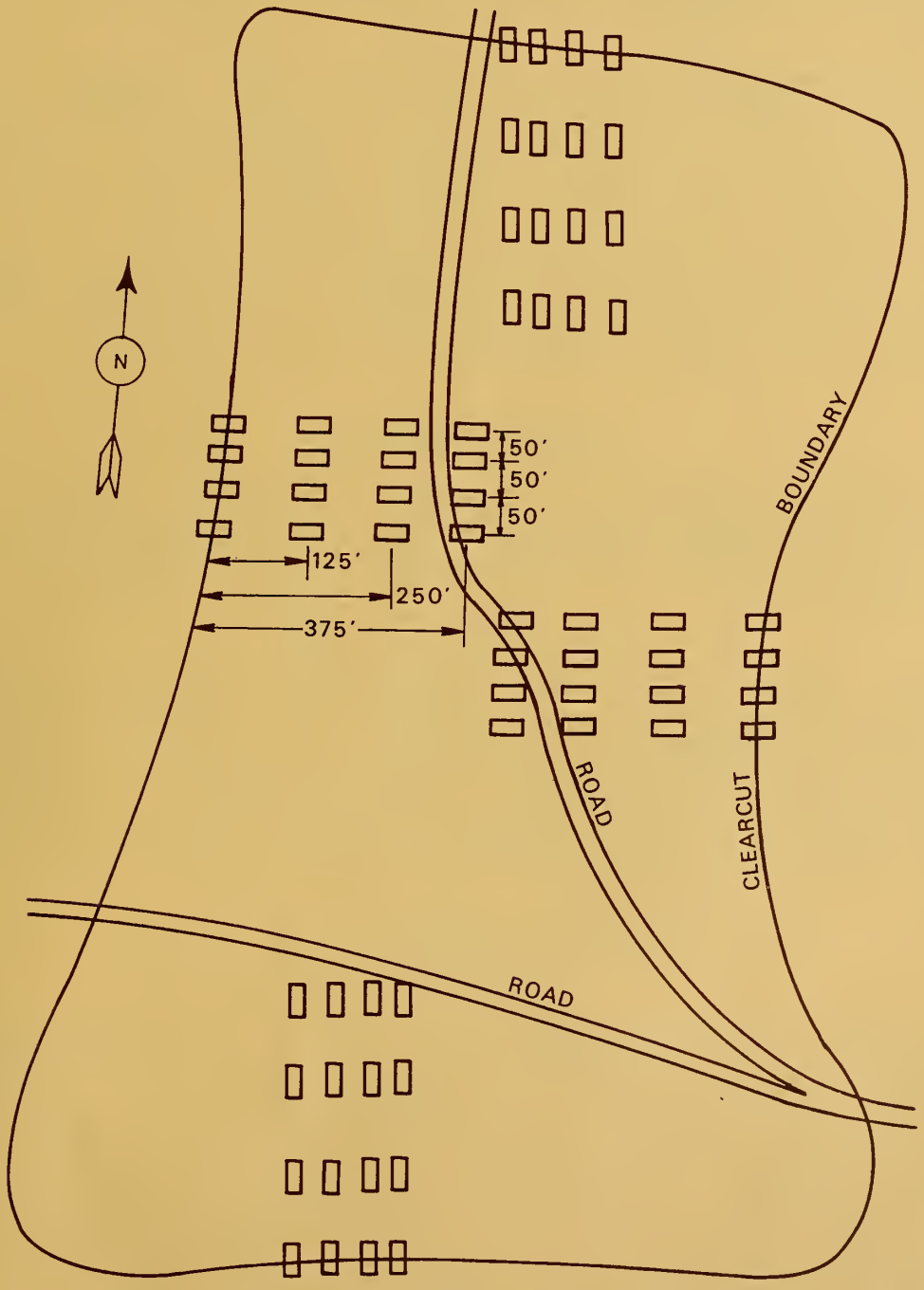

Figure 1.--Arrangement of seed traps and transects on clearcut.

were used in each transect group with four traps placed at 0, 125, 250, and 375 feet from the stand edge. One transect group was located on each side of the essentially rectangular clearcut for a total of 64 traps. The 1- by 2-foot seed traps used followed Herman's (1963) design with an additional crossmember in the top half of the trap to support heavy snow loads.

Trapping began during the 1967 seed year, but the mountain hemlock seed crop was insufficient for statistical analysis. In 1968, mountain hemlock produced a very heavy cone crop which provided the seedfall data reported here. Seeds were collected from the traps on about October 1 and November 1 and again the following spring as soon as snow conditions permitted. Seed soundness was determined by a cutting test. Mountain hemlock, which apparently produces medium to heavy cone crops at approximately 3-year intervals (Franklin 1968, Franklin et al. 1973), produced a medium crop in 1971. Collections were repeated for the 1971 seed crop following the same procedures.

STATISTICAL ANALYSES

Regression analyses were conducted to determine the relationship between distance from stand edge and both total and sound seedfall for each transect and the combined data. The regression model was of the form

$$\log_e (y+1) = a + b \left(\frac{1}{x}\right)$$

where y = number of seed and x = distance from stand edge. Covariance analyses were conducted to determine whether the regression surfaces (slopes and intercepts) for each transect were significantly different. Finally, regression of the ratio of sound to total seed on distance was carried out to determine whether the ratio varied with distance; this allowed us to draw inferences as to whether empty and sound seed differ in flight distance.

RESULTS

Not surprisingly, mountain hemlock seedfall is strongly correlated with distance from stand edge (fig. 2, table 1). Regression analyses of seedfall on distance are significant for all transects or cutting margins. The rapidity with which seedfall declines with increasing distance from stand edge was unexpected, however, for the small, winged mountain hemlock seeds. Sound seeds declined by about two-thirds from the amount at the stand edge in the distance of one-tree height (i.e., 125 feet) into the clearcut, generally falling to a level of less than 10 percent at 250 feet and beyond. The regression equations predict a somewhat more rapid decline in seedfall in the first 125 feet than the actual data indicate (table 1).

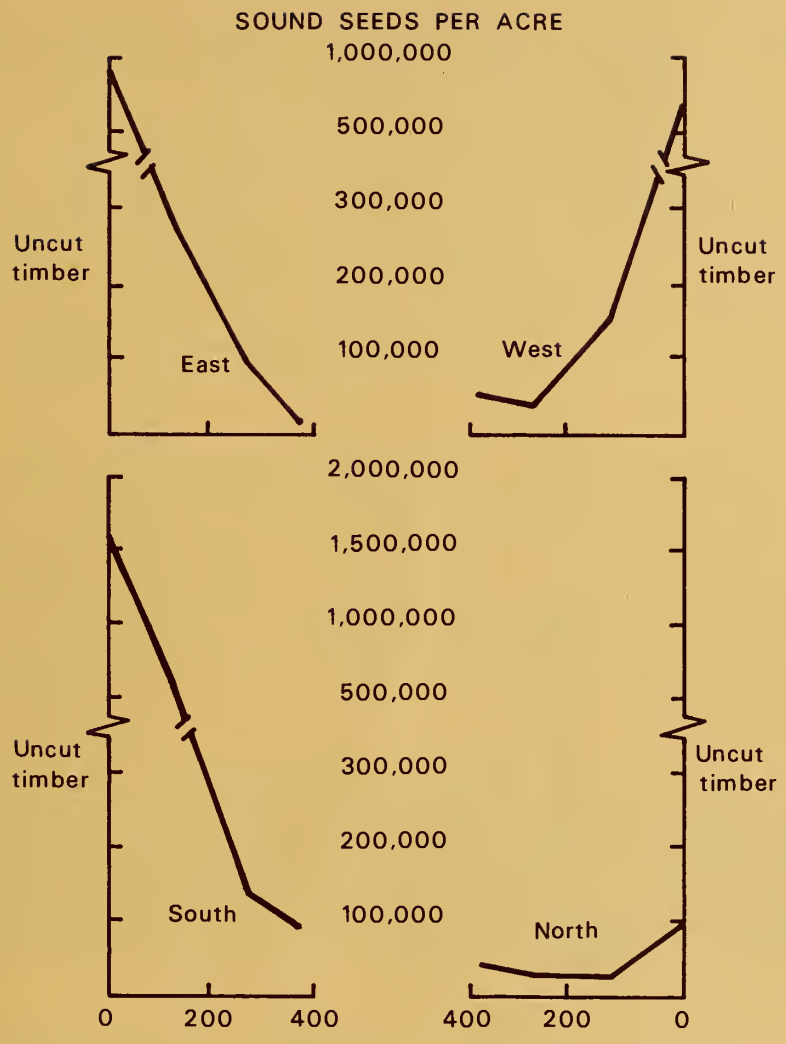

Figure 2.--Average mountain hemlock seedfall from the 1968 cone crop by clearcut boundary and distance from the stand edge.

Table 1.--*Numbers of sound mountain hemlock seed per acre from the 1968 seed crop by distance from stand edge and clearcut boundary*[1/]

Clearcut margin	Distance from stand edge (feet)			
	0	125	250	375
	Thousand seeds			
North	87	27	33	49
South	1,677	506	142	93
West	659	163	38	51
East	888	283	98	16
Average, all transects	828	245	78	52
Values predicted by regression analysis[2/]	[3/]524	77	77	77

[1/] Each figure (except for the "average" row) is based on sound seed collected in four 1- by 2-foot traps, converted to a per-acre basis, and rounded to the nearest thousand. Standard errors were calculated for each four-trap set; one standard deviation ranged from 340 to 6,806 sound seeds per acre (±) for the sets of traps at 375 feet, which had the greatest variation.

[2/] Based on the pooled data. Since there were significant differences in the regression coefficients, we are not justified in using the regression equation for the pooled data. We have included it simply to show the general form of the curves predicted by the individual regression equations.

[3/] Predicted value 1 foot from the stand edge.

Level of seedfall varies with transect or clearcut margin; covariance analyses indicated statistically significant differences between the regression coefficients for the four transects. Inspection of the data strongly suggests that the absolute amounts of seedfall as well as the slope of the regression line (regression coefficients) vary significantly with transect. A major factor affecting absolute numbers of seed (and possibly responsible for a part of the significant variation in regression coefficients as well) would seem to be the nature of the marginal stand. The transect with the highest seedfall is on the south margin which has the largest basal area of the four marginal stands; the north transect has the lowest seedfall per acre and by far the lowest basal area and trees per acre.

Initially it was hoped that use of four transects extending from different stand margins would enable us to draw some tentative conclusions about the major wind direction for dispersal, i.e., dry east winds versus winter storm winds from the southwest. No such inferences seem possible because of the large differences in stand density and total seedfall on each side of the clearcut. The statistically significant difference in regression coefficients does suggest the possibility of at least small differences in dispersal patterns from different stand margins, however.

Results have been presented and discussed in terms of sound seed only rather than total seed since analyses of both give essentially the same results. The ratio of sound to total seed did not vary significantly with distance from stand edge; this suggests that differences in seed flight distances of sound and empty seed are of no importance on small clearcuts of the type studied here. Our data do show some interesting seasonal variations in percent of sound seed, however.

Collection date	Sound	Total	Percent sound
October 1, 1968	104	158	65.8
November 1, 1968	667	961	69.4
Spring 1969	109	269	40.5
Total	880	1,388	63.4

The results of the seedfall study in 1971-72 were similar, although total seedfall was only about one-third as much as in 1968-69 (444 seeds collected). The proportion of sound seed was slightly higher--74.8 percent. Seeds collected on October 1 were much poorer (35.7 percent sound) than those collected in the spring (76.0 percent). The relationship between seedfall and distance from seed source was the same. The various clearcut boundaries again differed in total seedfall with the same ranking; the largest number of seed were collected in the transect adjacent to the southern boundary, fewest in the northern transect, and the east and west transects intermediate.

DISCUSSION AND CONCLUSIONS

Dispersal patterns on this 31-acre clearcut show a rapid decline in seedfall with distance from stand edge. Seedfall (in a bumper seed year) tends to plateau at a level of 50,000 to 100,000 sound seeds per acre (1 to 2 pounds) beyond one tree height and up to 375 feet from the stand edge, the maximum distance possible on this small cutting. Marginal stand conditions (number and size of seed-bearing trees) appear to strongly influence absolute amounts in the adjacent clearcut.

It might be logical to expect further decreases in seedfall beyond 375 feet, i.e., in central portions of larger clearcuts. Results of similar studies with other light-seeded species--Engelmann spruce (Roe 1967; Roe et al. 1970) and lodgepole pine (Dahms 1963)--suggest that further decreases in seedfall beyond 375 feet from the stand edge are very gradual. These studies also confirm the extremely rapid decline in seedfall between the stand edge and one tree-height distance into a cutting. The question as to what might happen to seedfall on a larger clearcut is probably academic in any case since few foresters would recommend clearcutting more than 30 acres of mountain hemlock forest in a single patch.

Larger mountain hemlock clearcuts (including the one studied here) have failed to restock adequately with postlogging natural regeneration of mountain hemlock even with the substantial seedfall reported here. This appears to confirm our suspicions that factors other than seed supply (such as frost and drought) are limiting natural regeneration on larger clearcuts. This is clearly the situation on some of the small (less than 10 acres), poorly stocked mountain hemlock clearcuts.

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